

## Claims

- [c1] A method to purify syngas, comprising:
- introducing a raw syngas stream containing excess nitrogen to a feed zone in a distillation column;
  - expanding a liquid bottoms stream from the distillation column through a liquid expander with a work output to form a cooled waste fluid stream;
  - rectifying vapor from the feed zone in the distillation column to form an overhead vapor stream of reduced nitrogen and inerts content;
  - cooling the overhead vapor stream in indirect heat exchange with the cooled waste fluid stream to form a partially condensed overhead stream and a relatively warm waste fluid stream;
  - separating the partially condensed overhead stream into a condensate stream and a purified syngas vapor stream of reduced nitrogen and inerts content; and
  - refluxing the distillation column with the condensate stream.
- [c2] The method of claim 1, further comprising cooling and expanding the raw syngas stream across a Joule-Thompson valve in advance of the introduction to the

feed zone.

- [c3] The method of claim 2 wherein the cooling of the raw syngas stream includes cross-exchange against the warm waste fluid stream and against the purified syngas vapor stream.
- [c4] The method of claim 1 wherein a liquid level in the distillation column is controlled by adjusting flow to the liquid bottoms stream expansion.
- [c5] The method of claim 1, wherein the waste fluid from the liquid expander comprises mixed vapor and liquid.
- [c6] The method of claim 5 wherein the warm waste fluid from the overhead vapor cooling consists of a vapor phase.
- [c7] The method of claim 1 wherein the liquid expander comprises a hydraulic turbine.
- [c8] The method of claim 1, further comprising producing the raw synthesis gas by reforming a hydrocarbon, wherein the reforming includes autothermal or secondary reforming with excess air.
- [c9] The method of claim 1, further comprising supplying the purified syngas vapor stream to an ammonia synthesis loop to form ammonia.

[c10] An ammonia process, comprising:

- reforming a hydrocarbon to form syngas, wherein the reforming includes autothermal or secondary reforming with excess air to form a raw syngas stream containing excess nitrogen for ammonia synthesis;
- cooling the raw syngas stream in a cross-exchanger;
- expanding the cooled raw syngas stream from the cross-exchanger;
- introducing the expanded raw syngas stream to a feed zone in a distillation column;
- expanding a liquid bottoms stream from the distillation column through a liquid expander to form a cooled waste fluid stream;
- rectifying vapor from the feed zone in the distillation column to form an overhead vapor stream of reduced nitrogen and inerts content;
- cooling the overhead vapor stream in indirect heat exchange with the cooled waste fluid stream to form a partially condensed overhead stream and a partially warmed waste fluid stream;
- separating the partially condensed overhead stream into a condensate stream and a purified syngas vapor stream of reduced nitrogen and inerts content;
- refluxing the distillation column with the condensate stream;

heating the purified syngas vapor stream in the cross-exchanger;  
heating the partially warmed waste fluid stream in the cross exchanger;  
supplying the purified syngas vapor stream from the cross-exchanger to an ammonia synthesis loop.

- [c11] The method of claim 10, wherein the waste fluid from the liquid expander comprises mixed vapor and liquid.
- [c12] The method of claim 11 wherein the warm waste fluid from the overhead vapor cooling consists of a vapor phase.
- [c13] The method of claim 10 wherein the liquid expander comprises a hydraulic turbine.
- [c14] In an ammonia process including the steps of reforming a hydrocarbon with excess air to form a raw syngas stream, removing nitrogen and inerts from the raw syngas stream by distillation wherein cooling is provided by process fluid expansion through an expander generator and wherein an overhead stream is partially condensed against a waste stream cooled by expanding bottoms liquid from a distillation column, and supplying syngas with reduced-nitrogen and inerts content from the distillation to an ammonia synthesis loop, the improvement

wherein the bottoms liquid is expanded through a liquid expander with a work output.

[c15] The improvement of claim 14, wherein waste fluid from the liquid expander comprises mixed vapor and liquid.

[c16] The improvement of claim 14 wherein the liquid expander comprises a hydraulic turbine.

[c17] The improvement of claim 14, further comprising expanding the raw syngas across a Joule–Thompson valve upstream of the distillation column.

[c18] Apparatus for purifying a raw syngas stream containing excess nitrogen, comprising:

means for introducing the raw syngas stream to a feed zone in a distillation column;

means for expanding a liquid bottoms stream from the distillation column through a liquid expander to form a cooled waste fluid stream;

means for rectifying vapor from the feed zone in the distillation column to form an overhead vapor stream of reduced nitrogen and inerts content;

means for cooling the overhead vapor stream in indirect heat exchange with the cooled waste fluid stream to form a partially condensed overhead stream and a relatively warm waste fluid stream;

means for separating the partially condensed overhead stream into a condensate stream and a purified syngas vapor stream of reduced nitrogen and inerts content; and

means for refluxing the distillation column with the condensate stream.

[c19] An ammonia process plant, comprising:

means for reforming a hydrocarbon to form syngas; wherein the reforming means include an autothermal or secondary reformer and means for supplying excess air to the autothermal or secondary reformer to form a raw syngas stream containing excess nitrogen for ammonia synthesis;

cross-exchanger means for cooling the raw syngas stream;

means for expanding the cooled raw syngas stream from the cross-exchanger;

means for introducing the expanded raw syngas stream to a feed zone in a distillation column;

means for expanding a liquid bottoms stream from the distillation column through a liquid expander to form a cooled waste fluid stream;

means for rectifying vapor from the feed zone in the distillation column to form an overhead vapor stream of reduced nitrogen and inerts content;

means for cooling the overhead vapor stream in indirect heat exchange with the cooled waste fluid stream to form a partially condensed overhead stream and a partially warmed waste fluid stream;

means for separating the partially condensed overhead stream into a condensate stream and a purified syngas vapor stream of reduced nitrogen and inerts content;

means for refluxing the distillation column with the condensate stream;

means for heating the purified syngas vapor stream in the cross-exchanger;

means for heating the partially warmed waste fluid stream in the cross exchanger;

means for supplying the purified syngas vapor stream from the cross-exchanger to an ammonia synthesis loop.